HEAD INJURY, MEMORY IMPAIRMENT AND OCCUPATIONAL SAFETY

(Technical Report)

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Abstract

The match between a worker's abilities and job requirements is among the most important determinants of safety in the workplace. Although considerable effort has been made to designing equipment and safety devices aimed at physical abilities, relatively little is known about matching mental abilities, as they may change, with job demands. A worker may suffer damage to the central nervous system because of exposure to neurotoxins or injury. In addition to the obvious impairments caused by severe head injury, approximately 30% of accident victims who have had minor head injury or whiplash report symptoms of the post-traumatic syndrome (headache, sex drive changes, personality change, sleep disturbance, memory deficits). Because these workers often return soon after their accident to the job, safety in the workplace is threatened.

The long term goals of this project are to enhance safety in the workplace, and improve the welfare of the worker and family, by identifying the match between mental abilities and job demands. As an initial step in achieving this goal, the focus of our research was on the development of neurocognitive tests that would be sensitive to early and specific changes in mental abilities after minor head injury and whiplash. We were not attempting to establish specificity and sensitivity in identifying members of a clinical population as a diagnostic entity. Participants were interviewed to obtain personal and medical history in one session, followed on subsequent days by two sessions testing a wide range of memory and cognitive abilities: immediate memory, working memory,

prospective memory, memory for stories, language, spatial and motor abilities. Participants were men and women who were (1) in an accident resulting in minor head or whiplash injury and reporting typical post-traumatic symptoms matched with control subjects with no previous injury or symptoms; (2) not in an accident but reporting memory and cognitive impairments matched with control subjects. These control groups were age, gender and education matched subjects for groups 1 and 2 above. Patients were referred by physicians and had no neurological, medical or neuropsychological evidence to account for their reported memory impairment.

Our results showed that as a group, patients with post-traumatic symptoms and patients with suspected early dementia were impaired on the wide range of cognitive tests. The two patient groups showed distinctive patterns of deficits. Those with head injury/whiplash were deficient compared to their controls on time-oriented tasks and language, whereas the others were deficient on memory and cognitive tasks.

The results for trauma victims in this study were not due to depression, drugs or being in litigation. Change over a one-year period was almost non-existent. Depending on the conditions and demands of the workplace, the impairments could place the person and/or their co-workers at considerable risk for injury. The cumulative effect of even minor deficits extending across a diverse set of abilities could lead to substantial mismatches between worker competence and job demands.

In addition to replicating and extending the study of trauma

victims, research should examine mismatches caused by exposure to neurotoxins and by the normal aging process. Improving safety in the workplace has widespread ramifications for the worker and the family, as well as industry, business and the government.

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typical post-traumatic symptoms [illegible]
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Alberta Occupational Health & Safety

Head Injury, Memory Impairment and Occupational Safety

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Problem

Injury to the central nervous system that occurs from accidents involving head trauma or whiplash or from exposure to chemical neurotoxins constitutes a threat to safety in the workplace. Given the insensitivity of current neurological and neuropsychological tests to detect many changes in cognitive functions, the immediate goal of this project is the development of a battery of tests to detect memory and cognitive impairment that could affect safe performance of a job, as well as to examine differential recovery of functions. These findings can be useful in assessing the competence of long-term employees to continue in their jobs, and for setting standards regarding the safe levels of exposure to hazardous chemicals. In the case of chemical exposure, complete elimination of hazardous gases from the work environment are often impossible, and reductions in the levels of toxins are expensive. What is needed is an adequate means of assessing the effects of different levels of chronic exposure on memory and cognitive functions to enable the determination of defensible safety standards. In the case of head injury, although the results of severe head injury are obvious, the putative dysfunction caused by minor head injury and whiplash have been controversial.

Objectives

Safety in the workplace must be considered in two contexts. The first concerns industrial accidents and their consequences for

the individual. The second concerns the consequences of long-term employment in hazardous environments. Accidents and long-term exposure to hazardous environments result in a wide range of impairments.

One of the common, least well studied, and most debilitating is injury to the central nervous system. Such injury to the brain occurs both in industrial accidents that result in overexposure to chemical neurotoxins (e.g., hydrogen sulfide, isocyanate, solvents), chronic exposure to low levels of neurotoxins, and trauma to the brain through concussion or whiplash injuries.

Memory and cognitive abilities are many and varied, and differences in the type of impairments induced by damage to the nervous system wll not be identified by the use of only one or a few different tests. Moreover, the traditional assessments are judged to be insensitive to all but rather gross declines in memory and cognitive deterioration. It was deemed imperative that new, more sensitive assessment techniques be developed that spanned many memory and cognitive functions. In fact, such developments are a major concern in all areas for which memory and/or cognitive impairments are at issue (Brooks, 1984; Levin, Benton & Grossman, 1982).

The goal of the present research was the development of a battery of memory and cognitive tests to meet these needs. Achieving this goal required several steps. First, tests were developed that are more sensitive to cognitive dysfunction than are those currently used. Moreover, these tests assessed a broad range

of abilities. Second, these tests were given to a large number of normal persons to establish a comparison base for defining impairment. It is critical that a broad age range be included such that a normative base is established to compare both younger and more senior workers. Third, the tests were given to persons suspected of having memory and cognitive impairments. There were several characteristics of this memory impaired group which would provide for the most careful scrutiny of the new tests. In this regard, the victims should be readily available and ones for whom neurological, electrophysiological, radiological, and other medical testing is as complete as possible. They also should be people showing clear clinical evidence (reports from family, friends, and physician) of memory impairment but for whom traditional neuropsychological assessments provide no evidence of impairment. This provided for a strong evaluation of the sensitivity of the newly developed assessment techniques. It was also advantageous if this population included some persons likely to recover while others would show permanent disabilities. This would have enabled a direct assessment of both cognitive impairment and differential recovery of functions.

In developing a set of tests to assess changes in memory and cognitive functions, it would have been most unwise to select an impaired population that has been poorly researched. A much more judicious approach was to select a population group that has received the most study, which in this case was people with minor head injury and whiplash. This allowed for comparisons of findings

with those of other researchers. It is only in this way that one could be assured that the new tests were more sensitive and could adequately categorize disabilities. Once one is assured of these advances, then the research can be extended to the assessment of more poorly researched causes of memory and cognitive dysfunction.

In order to achieve our goals, we first assessed changes in memory and cognitive abilities due to whiplash and minor closed-head injuries, incurred on or off the job, that might increase the risk for accidents in the workplace. Participants in the study included one group with head trauma and memory complaints, one group without previous head trauma but with memory complaints, and age, education and sex matched control groups for each of these groups. Participants performed several tests measuring a wide variety of cognitive functions.

Introduction

In a recent review of the theories of accident causation prepared for the Occupational Health and Safety Division, Harvey (1984) concludes that "There is every reason to predict that systems theory will be the major guide for the study of accidents and the prevention of accidents for the future" [p. 39]. Contemporary systems theories focus on primary human factors such as perception, memory, judgement, etc., and the relationship of these factors to particular workplaces. One clear objective of the systems approach is the matching of the memory and cognitive skills of the worker with those required by his or her profession. An important aspect of the present proposal was directed toward assessments of changes in memory and cognitive abilities that may pose problems for safety in the workplace.

Accidents in the workplace occur for a variety of reasons involving interactions between the environment and the person. The nature of the job places particular requirements and cognitive demands on the operator. Different combinations of spatial abilities, fast routine behavior, monitoring and planning abilities would characterize many tasks. The operator may have limitations in terms of these cognitive capabilities that may lead to poor and unsafe performance. In one instance, this mismatch may be due to inadequate procedures for personnel selection, or changes in the equipment and requirements of the job. However, the situation could also arise because of changes in the memory and cognitive abilities of the worker due to exposure to chemical substances or

head trauma or other sources of neuropsychological decline. Because the literature on behavioral toxicity is limited, our review will focus on head trauma, introducing the limited relevant literature on toxicity where appropriate.

Head injury is the most common etiology of memory disorder (Levin et al, 1984). Both British and American studies have shown that hospital admissions for head trauma have steadily increased during the past two decades (Jennett, 1983; Levin, Benton, and Grossman, 1982). The incidence of head injury involving loss of consciousness, post-traumatic amnesia, neurological signs of brain injury or skull fracture has been estimated by Annegers, Grabow, Kurland and Laws (1980) to be 247 males and 116 females per 100,000 persons. These figures approximate those of the National Head and Spinal Cord Injury Survey conducted in the U.S. in 1974. Studies which include milder trauma suggest much higher rates; about 600 per 100,000 (Caveness, 1977) and 430 per 100,000 in Field's (1976) study. The data from Kerr, Kay, and Lassman (1971) indicate that over 87% of the head injuries are incurred by people in the lower three socio-economic classes. Moreover, in these socio-economic classes, more admissions to neurological units were due to head injuries caused by industrial accidents (31.8%) than were caused by road accidents (26.9%). These data provide an underestimate of the percentage of work-related head injuries since an unknown proportion of the road accidents occurred when travel was a requisite part of the job, or the person was traveling to or from work.

Statistics compiled by AOH&S reveal that for the period of 1982-1984, there were 384 lost time claims for job related head trauma. Although the number of head injuries in the workplace is far from trivial, it is clear from both Canadian (Klonoff & Thompson, 1969) and U.S. statistics (Annegers, Grabow, Kurland, & Laws, 1980) that a high proportion of head injuries are not due to job related accidents. Consequently, the major issues for occupational safety are more extensive than the prevention of head-injury accidents in the workplace. Instead, the concern must be for the change in the accident risk for the person who suffered head trauma, regardless of where that accident occurred. This brief review of the literature indicates that an investigation of head trauma is of importance in its own right for several reasons: (1) The incidence of head trauma is very high. (2) There is a growing body of literature indicating substantial and relatively long-term changes in memory and cognitive functions, such as judgement and personality alterations with even mild to moderate head injury. (3) Currently used neurological and neuropsychological assessment techniques do not reveal these changes, because of inadequate assessments. (4) Cognitively impaired workers are unwittingly returned to the work force. Moreover, accidents resulting in whiplash injuries which are only partially included in the incidence rates cited above are likely to be even more problematic. A review of case histories reveals changes in memory, cognitive functions and personality similar to those occurring with mild to moderate head trauma. These changes

often continue for months or years after litigation issues have been resolved. Again, currently used neurological and neuropsychological assessment techniques indicate no or minimal abnormalities, yet these persons are unable to function in jobs in which they previously were competent. Moreover, some studies have shown that personality and intellectual deficits occur in the absence of traditional neurological indicators of physical or cognitive disabilities (Bond & Brooks, 1976; Gronwall & Wrightson, 1974; Sarno, 1984).

What is known about the effects of head injury on performance? Although considerable attention has been given to severe head injury (Jacobson, 1969; Jennett & Teasdale, 1981), less is known about mild and moderate head injury. Part of the reason for less research concerning mild-moderate head injuries has been the failure to observe neurological damage by standard tests such as CAT scan and EEG. In March 1983, Jane Brody (Globe & Mail) argued that there are countless people who have been ignored by the medical profession - "victims of the silent epidemic". These are people who apparently recover from head injuries but who have "subtle" intellectual and behavioral problems that impair their ability to work. Their symptoms are not understood, and they are often accused of malingering (Raskin, 1985). Identification of the cognitive changes is important for the safety of the individual and his/her co-workers, and imperative for rehabilitation techniques to be applied. As recently as June 1985, several neurologists, psychiatrists, psychologists and internists discussed the severity

of the symptoms involving headache, memory loss and personality changes and lamented the lack of tests to document these symptoms.

The current literature provides some data documenting the impact of minor injury on psychological functions. In a prospective study, Wrightson and Gronwall (1981), found that 60% of victims with compensation claims reported symptoms on return to work and 46% reported that they could not do their job as well as usual. Twenty per cent reported defects of memory, concentration and work capacity ninety days after the accident.

The symptoms include headaches, dizziness, memory problems, sleep and sexual disturbances (Binder, 1986; Coonley-Hoganson, Sachs, Desai, & Whitman, 1984), and are referred to as the post concussional or post-traumatic syndrome. Memory and cognitive dysfunctions are particularly pervasive and are among the few symptoms shown to exceed those reported by non-head injured people (Dikimen, McLean, & Lemkin, 1986).

The neuropsychological sequelae following minor head injury have been examined in several studies. In these studies, a sample of people, all of whom have suffered minor head injury are tested using a wide variety of standard neuropsychological tests (e.g., Halsted-Reitan) at baseline, one month or three months after the injury. The results usually show initial impairment followed by recovery measured at different time intervals in each study (Sikimen et al., 1986; Dikmen, Reitan, & Temkin, 1983; Levin, Mattes, Ruff, Eisenberg, Marshall, Tabaddor, High, & Frankowski, 1987; Gentilini, Nichelli, Schoenhuber, Bortolotti, Tonelli,

Falasca, & Merli, 1985; McLean, Temkin, & Wyler, 1983; O'Shaughnessy et al., 1984), or only mild impairment compared to a noninjured control sample when measured several months after the accident (Rimmel, Giordani, Barth, Boll, & Jane, 1981).

Barth et al. (1983) have suggested that the global measures of neuropsychological function used in the research studies may predict recovery from significant head injury. Such measures, however, may not be sensitive to more subtle changes that occur in information processing. Similarly, Stuss, Elyz, Hugenholtz, Richard, LaRochell, Poirier, and Bell (1985) noted that many of the currently used tests are relatively insensitive to many specific memory and cognitive deficits. Based on their data, using a variety of different measures, Stuss et al. (1985) concluded that head injury results in divided attention deficits in information processing that might be reflected in speed of processing or the amount of information that can be handled simultaneously. Unfortunately, Stuss et al did not separate mild from moderate injury.

Because the neurologic disturbance in whiplash (e.g., Berstad, Baerum, Locken, Magtad & Sjaastad, 1975; Drake, 1986; Ommaya, Faaa & Yarnell, 1968) and the presenting symptoms are similar (Balla, 1980; Barnatt, 1986) to those involving minor head injury, we also included people who had experienced whiplash.

Method

<u>Subjects</u>: Patients were referred by physicians and a neurologist. One group of 25 patients had memory and cognitive deficits in their everyday activities but had no medical (e.g. TIA's, multi-infarcts) or psychological condition (e.g. severe clinical depression) as a basis for their problems. These are likely to be at-risk for dementia, particularly Alzheimer's disease. The second group consisted of 59 patients (23 men and 36 women) showing symptoms of the post-traumatic syndrome sustained after a minor head injury (loss of consciousness less than 30 minutes) or whiplash. As determined by their referring physicians, there was no neurological or neurocognitive evidence for their problems from standard neurological examinations or psychological testing. In addition, a randomly selected subset of 89 subjects consisted of minor head injured and whiplash victims and an equal member of controls from this same sample were administered neurological examinations as a further standardized check for the study. These examinations included testing of cranial nerves, power and muscle group, tone, reflexes, coordination, detendon reflexes, sensation, gait and other tests as appropriate. All subjects fell within normal range, with the exception of one trauma subject showing sixth cranial nerve palsy not related to cognitive deficiencies.

The control subjects were selected from a larger group of 650 normal, community dwelling volunteers recruited for our study. Recruitment was based on advertisements to city employees (e.g.

fire, police, transportation departments), service clubs, community leagues, city associations. Controls had no history of head injury, neurological disorders or alcoholism.

Participants were informed that they would be asked questions about their physical and emotional health and that they would be given memory tasks. The goals and implications of the study were described. An informational letter was sent to volunteers repeating information given in the initial contact: statements about the purpose of the study, comments about the importance of their participation in contributing to knowledge about Edmonton seniors and a guarantee of confidentiality. At the start of each interview, the interviewer again stated that the information provided would be confidential, that the respondent could refuse any or all questions, and that the testing was not yet a diagnostic procedure. Signed consent for participation was obtained. In addition, each person was requested to give information regarding the name of their physician (and ophthalmologist, audiologist, etc., where appropriate) and asked for signed consent for us to consult with those persons. To avoid fatigue, the testing was divided into three one to one-and-a-half hour sessions conducted on separate days.

Session 1:

<u>Medical and Personal History Interview</u>: Participants and at-risk participants (or their relatives acting as informants) were asked to indicate highest level of formal education, marital status, income level (and/or that of a spouse for couples), and

type of position held (prior to retirement when appropriate). In addition, numerous questions regarding living conditions, physical and mental health, emotional stressors and medications were included.

Prospective Memory Task (PEN): Prospective memory is the ability to remember to do something at a future time (Harris, 1983). In this task, used by Read (1985), the person was told that later in the first session, they would be asked to draw and when asked to do so they were to ask for a red pen. About 10 minutes later, the person was provided with a pencil and piece of paper and asked to draw figures on the page. No further reminders about the request for a red pen were given.

Memory Functioning Questionnaire: This test is a shortened version of the Zelinski, Gilewski and Thompson (1980) metamemory (memory belief) questionnaire. Although there are other metamemory tests (e.g., Perlmutter, 1978; Herrmann, 1982), this test was designed for older adults and its psychometric properties have been studied (Gilewski, Zelinski, Schaie & Thompson, 1983). The 64-item test assesses overall self-evaluated memory ability, frequency of problems with specific matters (e.g., names, faces, directions), prose memory, seriousness of memory failure, and reminder techniques. This test provides measures of the person's perception of their own memory skills and these self-evaluations were compared to our objective assessments on retrospective and prospective memory. The comparison provides needed information about the extent to which health care professionals can rely on patient's

self assessments of memory skills.

Depression: The Geriatric Depression Scale (Brink et al, 1982; Yesavage, Brink, Lum, Huang, Adey & Leier, 1983) was used. The reliability and validity of this instrument for both older (see Yesavage et al., 1983) and younger people (Rule, Harvey & Dobbs, in press) is very good. The GDS has been used by some practitioners working with memory problems in the aged, both at Alberta Social Services and the Youville Geriatric Services.

Session 2 and 3:

In these sessions, the battery of cognitive tests was administered individually to participants. Three forms of the memory and cognitive tests were developed. Each form is identical in structure and procedure; the specific materials for the learning and memory tasks are different. This allows for re-testing individuals on subsequent years with a different form. One third of the sample received Form A, one third Form B, and one third Form C in the first year. Those that received Form A in the first year will receive Form B in the second year, and analogously for those receiving other forms. This minimizes year to year carry-over effects.

Vision and Audition: Sensory tests of vision and audition were administered. The form of the tests was based on extensive consultation with, and recommendations of, ophthalmologists and audiologists. The hearing test consisted of pure tone threshold determinations with a Beltone audiometer for tones of 500, 1000, 2000, and 4000 Hz.

Prospective Memory Task (Cued): In this task, administered in the second session, subjects are told that later in the session, they would be asked to draw a clock, at which point they were to turn the page over and write their best guess as to what time it was at the moment. They were told not to look at their watch, and there was no clock in the room. No further reminders were given. The cued recall occurred approximately 35 minutes later.

Prospective Memory Task (Uncued): On the third day of testing, subjects were instructed that later in the session, they would be given a booklet with a pink cover. It contained four pictures of household scenes in which they would be asked to find shapes. They were to turn over the booklet and write their best guess as to what time it was at the moment, without looking at their watch. There was no clock in the room. No futher reminders were given. The uncued recall task occurred approximately 35 minutes later.

Pattern or Word Recognition (Pointing): The participant was shown a set of cards having either the same words or patterns. Each card is unique in that the order of words changes from card to card. The task was to identify a word or pattern that differed in its position on each card. Participants were told not to touch the same location on the cards repeatedly nor (with words) to use the alphabet forwards or backwards to help remember which words had been chosen. A practice set of 6 cards was administered, followed by test sets of 8, 10 and 12 cards. The order of words and pattern tasks was counterbalanced over subjects.

Spatial Reconstruction: Subjects are shown three scenes (back yard, mountain, alley). One version presents objects in a spatially correct (organized) and in a spatially incorrect (disorganized) scene. Subjects are required to point to and name each of the five objects in each picture. Approximately 6 minutes later the subjects are then shown the objects and asked to place them on a plastic sheet exactly where they had been placed on the picture formerly seen. The order of organized and disorganized tasks was counterbalanced over subjects.

Prose Comprehension: Each of the three versions consisted of one passage from the logical memory subtest of the Wechsler Memory Scale and one passage developed specifically for this research. The prepared passages were stories with sequentially structured actions organized around familiar themes such as a family visit. The stories contain implicit and explicit information. Explicit information is that which is specifically stated in the story while implicit information is not explicitly stated but can be inferred from the content of the story. Recall and recognition of statements in the stories was obtained immediately following each passage. About 40 minutes later, delayed recall of the second passage was requested and followed by a recognition task. Some of the items in the recognition task was from the passages, some was incorrect, and some was based on material that was implied but not present in the passage. Immediate and delayed recalls were coded for the number of ideas that were accurately recalled and for the number of inferences that intruded into the recall.

Semantic Fields Task: This task measures semantic memory and is used to tap aphasia. Seven pictured target nouns taken from the Snodgrass & Vanderwart (1980) norms that are of high rank within their superordinate category (Battig-Montague, 1969) were placed before the person one at a time. The person was asked to name the object, and then listen to a series of 12 spoken stimulus words per target. Of these, six were unrelated buffer-words and six bore specific relationships to the target, including identity. Subjects indicated, by raising a hand, as soon as they recognized some relation between the target and the recorded stimulus word. The associative relationships between the picturable targets and the six related stimulus words were the following: Superordinate, the name of the semantic class of which the target is a member; Attribute, adjective describing a physical feature of the target; Contrast Coordinate, another member of the same superordinate class; Function Associate, verb designating action carried out by or upon the target; Function Context, situation in which the target occurs or another situationally determined object; Identity, the name of the object itself. Goodglass & Baker (1976) scoring procedures were used.

Paired Associate Learning: The paired-associate task included four word pairs that were semantically related and four that were unrelated. Half of the related and unrelated pairs were concrete words whereas the other half were abstract. The items were equated for word frequency. The items were presented for three trials in different orders with the study-test procedure.

Direction Following: The person was asked to imagine him or herself walking through the streets of a city and to trace, with pen, a specified route on a copy of an aerial photo of an actual city (magnification 1:5000). As well as a practice route of four turns, there were two test routes of six turns each, one where the person proceeded away from him/herself and one where he/she had to mentally rotate him/herself 180 degrees and imagine walking back toward his/her present location.

Digit Span: The forward and backward digit span tasks from the WAIS were administered.

Working Memory: This task (Dobbs & Rule, 1989) is an ongoing memory task that requires the manipulation of information in immediate memory. In this task, a series of digits was presented to the person, who was to repeat them in one of three delays: 0-lag, 1-lag, and 2-lag. In the 0-lag, the person was merely required to repeat each digit immediately after it had been presented. In the 1-lag task, the person was required to repeat the number that was one prior to the digit just presented. Finally, in the 2-lag task, the person was required to repeat the number that came two before the number just presented.

Hidden Figures: This task involved finding different types of forms in photographs of real life settings. The forms were outline drawings of: an object, a part of an object, an area of background, and the outline of two different parts of objects that overlapped. After being shown one of the forms, the person was asked to locate it in the picture and trace the outline in pen.

These pictures included scenes of kitchen counters and appliances, dining room tables, an open refrigerator, cupboards, and tool bench from a workshop. The forms that the participants searched for included objects and parts (e.g., labels or handles) that they frequently search for, as well as forms which require that they decompose these forms to create new shapes. These settings were selected because they include scenes that are traditionally feminine and scenes which are traditionally masculine.

Word Fluency (Verbal Production): Verbal production abilities were assessed in three ways. Participants were asked to generate all the words they could think of that begin with a particular letter (e.g., F or S), that were from a semantic category (e.g., animals), or search memory for particular words (give a word from a specified taxonomic category that begins with a specified letter). The items for the latter task varied in difficulty from easy (a fruit that begins with the letter A) to those involving more extensive memory search (a fruit that begins with a W).

Motor Tasks: For one task, people were instructed to place clevis pins in holes in a board facing them and to secure the pins with a cotter pin. Two practice trials were given. The number completed in 30, 60, 90, 120, 150, and 180 sec. was recorded. For another task, people were given tweezers to place nails in a hole in a plate in front of them. After two practice trials, the number of nails placed in 30, 60, and 90 sec. was recorded.

Results

Because we tested two pathological populations (head/whiplash

injury) and people with reported memory deficits (at-risk for Alzheimer's disease) and compared their performance to age, education, and gender matched control subjects, we will present the data for each in separate sections and then draw overall conclusions.

Head and Whiplash Injured Patients

Descriptive Characteristics. The trauma subjects were matched against an age, education, and gender matched control group. The mean age and education level were 42.44 years and 12.90 years, respectively, for the injured group and 43.85 and 12.91 years for the control group. Both groups had adequate vision and audition. The injured group were more depressed (Mean=12.07 vs 3.36) than were their controls, although their scores were not in the range of severely clinically depressed. Occupation covered the range from unemployed, skilled and unskilled labour to professionals.

The percentage of injured people having had head trauma was 50.0% men and 19.4% women; whiplash was 36.4% men and 52.8% women and both was 13.6% men and 25.0% women; with 2.8% of women sustaining other injuries and 1 man responding unknown to the question. The percentage of subjects who had reported personality change was 74.25%, sex drive change was 61.35%, headaches was 85.0%, memory change was 77.55%, and sleep disturbances was 82.2%. Injuries occurred from auto accidents (80.65%), pedestrian accidents (3.55%), falls (10.1%), and other (5.75%). The mean time since their most recent accident was 3.2 years. 30.5% had lost consciousness, 59.3% had not lost consciousness 6.7% were unsure

and 3.3% were missing data. Of those who had lost consciousness, the range was from 1 to 30 min.

Analysis of variance showed that there were no differences in age and education of the trauma versus control conditions. Women were somewhat less educated than men (Ms = 12.43 vs. 13.65), $F(1,114) = 4.71$, $p < .05$. The trauma group was more depressed than the non-trauma group (Ms = 11.57 vs. 3.64), $F(1,72) = 34.00$, $p < .002$. Women reported being more depressed than did men (Ms = 8.94 vs. 5.78), $F(1,114) = 6.62$, $p < .011$.

Several types of analyses were done. Analyses of variance were carried out to assess overall performance differences between trauma and non-trauma groups. The number of subjects in each analysis varied somewhat because of missing data. Newman-Keuls test was used to compare differences when three or more cells were significantly different using analysis of variance. Cells having common subscripts did not differ significantly from each other ($p > .05$).

Another purpose of the analyses of variance was to ensure that the variables were producing the anticipated effects within each group, regardless of whether those variables differentiated between the groups. These assessments provide important information in cases where group differences are not found. This is because the absence of group differences cannot be attributed to ineffective paradigms or variables if they are shown to produce typical effects. Discriminant analyses were conducted to assess those variables that differentiated the performance on the tasks by each

of the patient groups from their respective control groups. These analyses also served to ascertain the percent of cases correctly classified. In this way, it was also possible to identify whether distinctive patterns characterized the two patient groups.

The predictor variables of relevance to the trauma group also were of interest. Among the potential predictors of cognitive deficits, several were examined, grouped into separate regression analyses. Stepwise regressions were used. The model followed was to include the variable considered most important last to see the magnitude of its contribution after eliminating other sources of variance.

Scoring procedures for each test were developed. These are presented in detail elsewhere (Dobbs and Rule, 1990).

Two sets of analyses were done on the data from the minor trauma group and the non-trauma control group. One set of analyses was based on data from Year 1 and Year 2 and one set was based on data only for Year 1 (a larger sample). Because there were few differences between year one and two, the year one results based on the larger sample are reported here.

ANALYSIS OF VARIANCE

Multivariate Analyses of Variance: Three sets of multivariate analyses based on groupings of the dependent measures were calculated to accommodate the large number of dependent variables. The learning memory and non-verbal cognition variables (paired associates, digit span forward and backward, abstract pattern and word pointing tasks, working and

prospective memory) yielded a significant Hotellings **T** (9,106) = 2.90, $p < .01$. The verbal tasks (prose recognition, semantic fields and word fluency) yielded a significant Hotellings **T** (7,98) = 3.78, $p < .01$. The spatial and motor tasks yielded a significant Hotellings **T** (8, 101) = 3.37, $p < .01$. Consequently, Univariate ANOVARs were performed and are presented in the following pages.

Paired Associates: Analyses of variance were conducted with two conditions (trauma, non-trauma) and sex (men and women) assigned between groups and trials (1, 2, 3), relatedness of items (related, unrelated) and concreteness of items (abstract, concrete) assigned within conditions. Several effects were significant on proportion correct scores. As is usually found, there was a Trials effect, with reliable increases in performance (by Newman Keuls test, $p < .05$) from Trial one ($\underline{M} = .60_a$) to Trial 2 ($M=.81_b$) and from Trial 2 to Trial 3 ($M=.88_c$), F(2,228 = 209.39, $p < .001$. Performance was significantly better on related (M=.87) than on unrelated (M=.66) items, $F(1,114) = 154.88$, $p < .001$. A significant Trials X Relatedness interaction showed that differences in performance over trials were greater on unrelated items, $F(2,228) = 34.12$, $p < .001$. Concrete items were learned better than abstract items (M=.86 vs .67), $F(1,114) = 114.50$, $p < .001$. A Relatedness X Concreteness interaction showed that the poorer performance on abstract than concrete items occurred more for unrelated than for related items, $F(1,114) = 41.02$, $p < .001$. Considered together, these effects confirmed results for the trials and the concreteness effect

typically reported in the literature, and attest to the effectiveness of the paradigm with these subjects.

A significant Condition X Relatedness interaction, $F(1,114) = 5.91$, $p < .05$ showed no differences between trauma and non-trauma condition ($M = .87$ vs $.87$) on related items but differences on unrelated items ($Ms = .62$ vs $.70$).

The proportion correct for the delayed recognition test showed only that trauma subjects performed slightly worse than did non-trauma subjects ($Ms = .96$ vs $.99$), $F(1,114) = 4.41$, $p < .05$.

<u>Digit Span</u>. The Digit Span Forward (number of correct items) only showed that women performed worse than men ($\underline{M} = 6.31$ vs 6.91), $\underline{F}(1,112) = 5.22$, $\underline{p} < .05$. The Digit Span Backward also showed only that women performed worse than did men ($\underline{M} = 5.00$ vs 5.54), $\underline{F}(1,114) = 5.07$, $\underline{p} < 05$. A combined analysis showed that women did worse than men ($\underline{M} = 5.69$ vs 6.25), $\underline{F}(1,112) = 7.37$, $\underline{p} < .01$ and performance was worse in the backward than forward span test ($\underline{M} = 5.22$ vs 6.58), $\underline{F}(1,112) = 116.57$, $\underline{p} < .001$.

<u>Working Memory</u>. Working memory results (number correct to first error) showed that there were significant declines in performance from Lags 0 to 2, $\underline{F}(2,288) = 63.41$, $\underline{p} < 001$, with mean values of 10.00_a, 8.64_b, and 6.55_c, (Newman Keul's test, $\underline{p} < .05$), verifying previous results (Dobbs & Rule, 1989). A significant Sex main effect was modified by Lag conditions, $\underline{F}(2,228) = 3.50$, $\underline{p} < 05$. Newman Keuls analysis showed that men's performance did not decline until Lag 2 ($\underline{M}s = 10.00_a$, 9.31_a, 7.53_b respectively) whereas women declined with each Lag condition ($\underline{M}$s

$= 10.00_a$, 8.23_b, 5.84_c respectively).

A significant trauma condition main effect, showing that non-trauma conditions yielded better performance than trauma conditions ($\underline{M}$ = 8.84 vs 7.98), $\underline{F}(1,114) = 14.54$, $\underline{p} < .001$, was modified by Lag condition. Table 1, presenting the mean values for this interaction, shows that performance in the non- trauma condition declined only on Lag 2 whereas it declined in the trauma condition on each lag condition, $\underline{F}(2,144) = 3.06$, $\underline{p} < .05$).

Table 1

Number Correct to First Error as a function of

Trauma and Lag Conditions

Lag	0	1	2
T	9.88_a	7.58_b	5.66_c
NT	10.00_a	9.69_a	7.14_b

Prospective Memory. Performance on the pen task was significantly worse for trauma (M = .81) than for non-trauma subjects (M = 1.00), $F(1, 112) = 9.77$ $p < .01$; and for women (M = .86) compared to men (M = .98), $F(1, 112) = 4.05$ $p < .05$. These main effects were modified by an interaction showing no differences between non-trauma men and women (Ms = 1.00 vs 1.00) but worse performance for women (M = .72) than men (M = .95) in the trauma condition $F(1,112) = 5.05$, $p <$ 05).

On the uncued prospective memory task, performance was better for non-trauma (M = .85) than trauma subjects (M = .61) $F(1,114) = 8.10$, $p < .005$. Similarly, non-trauma subjects performed better than trauma subjects on the cued task (Ms = .91 vs. .75), $F(1,114) = 4.93$, $p < .05$.

Pointing Tasks (Patterns and Words). Performance on the pointing (frontal) tasks was scored using a lenient and a strict criterion. The proportion correct (lenient) for abstract pattern stimuli showed better performance on 8 rather than on 10 or 12 items ($M=.88_a$, $.85_b$, and $.85_b$), $F(2,216) = 3.33$, $p < .05$. Using a strict criterion of number correct to the first error, performance was better on 8 than on the 10 and 12 items (Ms = $.77_a$, $.68_b$, $.66_b$ respectively), $F(2,216) = 6.63$, $p < .01$.

On the pointing (frontal) task using abstract words, performance for trauma conditions was worse than for the non-trauma condition (_M_s = .88 vs .90 respectively), $\underline{F}(1,112) = 3.99$, $\underline{p} < 05$. Performance was worse on 8 compared to 10 and 12 items (_M_s=$.92_a$, $.88_b$, $.88_b$), $\underline{F}(2,224) = 14.82$, $\underline{p} < .001$. The criterion was the proportion of correct identifications. There was a significant sex X word interaction showing that men did better than women on only the 8 words, $\underline{F}(2,224) = 4.49$, $\underline{p} < .05$. Using a strict criterion (total correct to first error/number of words), similar main effects were found. Trauma subjects performed worse than non-trauma subjects (_M_s = .75 vs. .83), $\underline{F}(1,112) = 6.93$ $\underline{p} < .01$ and performance was worse on 10 and 12 words (_M_ = $.77_b$ and $.74_b$) than for 8 words (M = .87), $\underline{F}(2,224) = 16.47$, $\underline{p} < .001$. There were no differences on the two perseveration measures.

Prose Recognition. There were no reliable effects of trauma condition on number correct averaged overall, average of wrong items, and inference items on the Wechsler test. There were condition differences on the Dobbs-Rule task, showing that trauma subjects recognized fewer items than non-trauma subjects on the average of all types of items (_M_s .63 vs. .66), $\underline{F}(1,114) = 9.15$, $\underline{p} < .01$ on the average of the verbatim items only (_M_s = .73 vs. .87), $\underline{F}(1,114) = 9.71$, $\underline{p} < .01$, and on the average of the remaining (non-inference) items only, (_M_s = .89 vs. .96), $\underline{F}(1,114) = 5.86$, $\underline{p} < 05$.

Semantic Fields. The proportion correct over related pictures 1-7 of the Semantic Fields test showed that the

identical, superordinate and physical attribute were identified more correctly ($\underline{M}s=1.00_a$, $.98_a$, $.97^{ab}$) than the functional associate ($\underline{M}=.94_b$), and the functional context ($\underline{M}=.88_c$) and contrast coordinate ($\underline{M}=.56_d$), $F(5,570) = 145.19$, $\underline{p} < .01$). No differences between groups were obtained.

Word Fluency. People in the trauma condition compared to the non-trauma condition produced fewer words to the letter cues ($\underline{M}s = 10.18$ vs 12.27), $\underline{F}(1,108) = 9.22$, $\underline{p} < .01$, fewer total number correct ($\underline{M}s = 9.79$ vs 12.05), $\underline{F}(1,104) = 10.91$, $\underline{p} < .001$, and had fewer errors ($\underline{M}s = .02$ vs $.09$), $\underline{F}(1,104) = 12.64$, $\underline{p} < .001$. Men did worse than women ($\underline{M}s = .12$ vs. $.01$), $\underline{F}$,$(1,104) = 12.62$, $\underline{p} < .001$, with non-trauma men performing poorer than trauma men, non-trauma women and trauma women ($\underline{M}s = .24$ vs $.00$, $.00$, $.03$ respectively), $\underline{F}(1.104) = 21.09$, $\underline{p} < .001$. There were no perseveration differences.

A fewer number of members of categories was produced in the trauma ($\underline{M} = 8.61$), than in the non-trauma condition ($\underline{M}=10.20$), $\underline{F}(1,106) = 8.19$, $\underline{p} < 01$. There were fewer correct items produced in the trauma (M=6.02) than in the non-trauma ($\underline{M}=8.52$) condition, $\underline{F}(1,108) = 15.65$, $\underline{p} < .001$. There were no differences in the number of errors, perseverations or near misses.

The more constrained fluency test (category and first letter cues) was analyzed with condition and gender assigned between subjects and category associates (high, medium and low) assigned within subjects. A significant category effect was modified by a Condition X Sex X Category effect, $\underline{F}(2,228) = 4.05$, $\underline{p} < .05$. Table 2 illustrates the pattern of results. The major pattern

showed no differences between sex or condition in the high associate condition for the proportion of correct responses. Performance decreased for the medium and low associate conditions as compared to the high associate items, but then there was no overall effect of trauma.

Table 2

Mean Correct Fluency Scores: Category-Letter Task

Associates:	Hi	Med	Low
Trauma Men	$.94_{a}$	$.67_{bc}$	$.80_{b}$
Women	$.95_{a}$	$.69_{bc}$	$.56_{c}$
Nontrauma Men	$.97_{a}$	$.80_{b}$	$.71_{bc}$
Women	$.94_{a}$	$.75_{b}$	$.69_{bc}$

Time differences were found for the two sexes with women taking more time (M = 9.19) than men (M = 7.37, F(1,114) = 4.37), p < 05. The associative relationships also produced an effect (2.83, 10.52 and 12.10) for the high, medium and low, respectively, $F(2,228) = 101.79$, $p < .001$.

Direction Following. Number of seconds taken for the Direction following forward task was greater in trauma (M = 33.32) than control (M = 26.39) conditions, $F(1,111) = 16.03$, p < .001, for women (M = 32.04) than for men (M=26.50), $F(1,111)$ = p < .001. The interaction between condition X sex showed no differences between trauma conditions for men but trauma women took longer than any other group, $F(1,111) = 8.16$, p < 005. Proportion correct showed a similar interaction (see Table 3), $F(1,112) = 6.91$, $p < .01$.

Table 3

Proportion Correct Direction Following Responses as Function of Trauma and Gender Conditions

	Men	Women
Trauma	1.00_a	$.79_b$
Non-trauma	$.91_{ab}$	$.97_a$

Proportion of delays over all 6 trials and proportion correct over all 6 directions showed identical patterns. There were no reliable differences for the proportion hesitations over the total trials, proportion of repetitions, self-corrections or block errors. Proportion of direction errors (Condition X Sex) again showed women trauma victims to make more errors.

Time taken to perform the direction back task was longer for trauma (M = 49.12) than non-trauma (M = 39.60) victims, $F(1,97) = 7.08$, $p < .01$, and for women (M = 47.21) than for men (39.34), $F(1,97) = 6.80$, $p < .01$. Mean number of correct responses showed better performance by men (M = .84) than women (M = .69), $F(1,110) = 3.94$, $p < .05$. The non-trauma (M = .88) performed better than the trauma (M = .61) victims, $F(1,110) = 8.12$, $p < .01$. A condition x sex interaction showed the female trauma victims' performance differed from that of women in non-trauma condition (M = $.49_b$ versus $.89_a$, $.82_a$, $.86_a$), $F(1,110) = 5.15$, $p < .05$. A similar interaction occurred on the proportion correct over all six directions, $F(1, 112) = 6.01$, $p < .05$. Finally, men showed fewer delayed responding (M = .15s) than did women (M = .28s) over all six directions, $F(1,102) = 5.68$, $p < .05$. There were no differences on hesitations, repetitions or self-correct

responses. The proportion of errors over all six directions yielded the familiar pattern in a significant interaction, $F(1,112) = 5.83$, $p < .05$. People in the trauma conditions made more block errors than those in non-trauma conditions ($Ms = .03$ vs .01), F 1,112 = 4.08, $p <$ 05.

Hidden Figure. The Condition and Sex analysis included within group variables of picture type. Mean number correct on the real life hidden figures test showed only parts were more difficult, background was easier to identify than was a part or the background ($Ms=.54_c$, .71a, $.59_{bc}$, $.63_{bc}$, respectively), $F(3,342) = 8.50$, $p < .001$.

More time was taken to identify items by trauma than non-trauma people (M = 19.31 vs 14.42, respectively), $F(1,114) = 12.57$, $p < .001$, for background, and parts than for an object ($Ms=23.70_a$, 22.60_a, and $4.66_{c)}$ with a part falling in between ($M = 16.51_b$), $F(3,34) = 98.14$, $p < .001$.

Spatial Memory. Analysis of the spatial task measures of correct placement for the scenes with organized and disorganized objects showed no effects. Angle of rotation for disorganized objects was significantly greater for the trauma than for the control subjects, (Ms = 10.16 vs 3.33), $F(1,110) = 6.82$, $p < .01$. There were no condition differences for angle of rotation on the organized object scenes.

Motor Performance. The two motor tasks yielded several significant results. The mean number of clevis pins completed at 30, 60, 90 and 120 seconds differed significantly for time, showing that cumulative number completed increased linearly from

30, 60, 90 to 120 seconds ($\underline{M}$s = 5.18_d, 10.41_c, 15.89_b, 21.42_a), $\underline{F}(3,324) = 2{,}199.16$, $\underline{p} < .001$. The mean values for the significant, $\underline{F}(3,324) = 3.46$, $\underline{p}$ < 05, interaction are presented in Table 4, showing that the groups did not differ only in the 30 sec. condition.

Table 4

Mean Number of Clevis Pins Completed as
a Function of Condition and Time

	TIME			
	30s	60s	90s	120s
Trauma	5.01_g	9.94_f	15.23_d	20.57_a
Nontrauma	5.36_g	10.88_e	16.55c	22.27_a

The mean number of nails completed at 30, 60, 90 seconds was reliably different according to Condition, $\underline{F}(1,114) = 15.96$, $\underline{p} < .001$, Sex, $\underline{F}(1,114) = 8.17$, $\underline{p} < .01$ and Time $\underline{F}(2,228) = 1546.71$, $\underline{p}$ < 001. These were modified by interactions. As seen in Table 5, the significant Condition X Time interaction showed that the performance of the <u>control</u> group increased linearly over time and this increase was greater than for the trauma group, $\underline{F}(2,228) = 11.63$, $\underline{p} < .001$.

Table 5

Mean Number of Nails Placed as a Function of Condition and Time

Time	30s	60s	90s
Trauma	5.56_f	10.98_d	16.90_b
Nontrauma	6.86_e	13.62_c	20.56_a

The Sex X Time interaction showed that the overall better performance of men was greater than women over time, $\underline{F}(2,228)$ =

8.28, p < 001.

Table 6

Mean Number of Nails placed as a Function of Gender and Time

Time	30s	60s	90s
Men	6.70e	13.33c	20.35a
Women	5.90f	11.65d	17.69b

Metamemory. People having had trauma compared to those not having trauma reported having memory problems more often (Ms = 4.04 vs 5.27), $F(1,106) = 40.97$, $p < .001$, greater memory problems overall, (Ms = 3.85 vs 5.10), $F(1,100) = 26.87$, $p < .001$, greater mean retrospective memory problems (Ms = 4.02 vs 5.06), $F(1,108) = 27.74$, $p < .001$, greater prospective memory problems (Ms 4.10 vs. 5.47), $F(1,108) = 30.01$, $p < .001$, greater mean problems with ongoing tasks (Ms = 3.99 vs 5.47), $F(1,108) = 46.22$, $p < .001$, and greater mean memory problems now than 1, 5, 10 years ago (Ms = 2.76 vs 3.85), $F(1,106) = 39.32$, $p < .001$. They also indicated more serious problems with ongoing tasks, retrospective and prospective memory problems, reading novels and newspapers. They did not differ in reported use of memory aids.

Although there were reliable differences showing more difficulties by the people in the trauma conditions on several other measures (i.e., remembering things in the past, seriousness of memory problems, memory years ago compared to now, memory problems overall, prospective memory, retrospective time, seriousness of prospective problems, perspective seriousness of ongoing task problems), these were modified by interactions with Sex. Newman-Keuls task on the Sex X Condition interactions

showed that control group women reported better memory than subjects in any other condition.

Predictors: Regression Analysis of Performance Measures

Demographic: See Table 6 for results of regression analyses on trauma group considering Sex, Education and Age. Age was a significant predictor of paired associates learning, working memory (Lag 1), prose recognition, verbatim prose memory items, pointing patterns correct, hidden figures time (with sex of subject), hidden figures number correct, clevis pin over 120s, nails over 90s (with sex of subject), word fluency correct. Sex of the subject, in addition to above, predicted direction following number correct and time. Education predicted digit span forward, digit span backward, word fluency (letter), and correct performance on the word pointing task. There were no predictors of prospective memory, prose recognition inferences, pointing patterns perseverations, semantic fields, word fluency letter or category perseverations, spatial organized or disorganized pictures.

Accident: Regression analyses results are presented in Table 8 for accident variables. The variables were: number of head injuries, head injury, whiplash, number of years since the accident, loss of consciousness and age at time of the accident, litigation. Age at the time of the accident emerged as a predictor on paired associate learning, digit span backward, working memory (Lag 1), prose recognition (verbatim and inference), direction following time, pointing task patterns, hidden figures (time and correct), clevis pin, fluency (category;

letter), spatial memory disorganized picture. Time since the accident predicted performance on the Nail task (over 90 seconds) and semantic field related correct items. Head injury predicted word fluency perseveration, and loss of consciousness predicted spatial construction on the disorganized picture. Litigation predicted performance on only two variables. Moreover, so few subjects were in litigation that it is not interpreted as a contaminating variable in this research.

Health: Table 8 presents the results of regression analyses for the health variables that included physical health, emotional health, psychotropic drugs. Significant predictors were identified on only six of the twenty four measures. Physical health predicted paired associate learning, hidden figures time and number correct, motor performance on the nail task over 90s, and word fluency performance with letter stimuli. The number of psychotropic (and painkiller) drugs predicted prose recognition verbatim performance and semantic fields related correct scores. Mental health did not predict any performance measure.

Depression: The relative influence of metamemory and depression was examined by regressing scores from reported memory problems overall, reported memory abilities now compared to the past, and depression. Depression significantly (and solely) predicted paired associate learning, forward and backward digit span, prospective memory, motor performance (nails over 90 sec), word fluency with letter and category stimuli. Memory problems overall predicted working memory (Lag 1), direction following correct, and motor performance (clevis pins: over 120 sec).

Memory difficulties now compared to the past predicted number correct in the abstract patterns pointing task, and placement errors (distance) on the organized picture reconstruction task. Table 10 presents these results.

Post-Trauma Symptoms: Regression analyses of the post-traumatic syndrome variables that included reported personality change, sex drive change, severity of headache and memory change yielded significant predictors on eight out of twenty four measures. As seen in Table 10, perceived personality change predicted paired associate learning, forward digit span, working memory (Lag 1), and hidden figures correct. Reported change in sex drive predicted prose recognition inferences. Severity of headache predicted direction following correct responses and word fluency number of correct words in the task with letter cues.

Significant Predictors from Regression Analyses. Table 12 presents the regression results using those variables that were major predictors on several of the performance measures in the previous regression analyses: number of head injuries, age at accident, education and depression. Learning and motor performance was predicted by depression, followed by age. Digit span forward and performance on the pointing (words) was predicted by education. Digit span backward was predicted by education, age at accident and depression; word fluency letter correct by education and depression. Word fluency for categories was predicted by age at accident. Depression predicted prospective memory and spatial reconstruction of organized pictures. Age at the time of accident predicted hidden figures (time and correct),

motor performance (clevis pin), working memory (Lag 1), verbatim prose recognition and pattern pointing (followed by depression).

<u>**Discriminant Analyses**</u>

In order to analyze an acceptable number of dependent variables, given our sample size, three separate discriminant analyses were done. One analysis (Learning, Memory and Non-verbal Cognition) included paired associate learning, forward digit span, backward digit span, working memory (Lag 1), prospective memory, and the two (abstract patterns vs words) pointing tasks. Wilks Lambda was .80, $X^2 = 24.13$, $p < 005$. Pooled within group correlations between discriminating variables and canonical discriminant function showed the following:

<u>Function 1</u>

Working Memory		.84*
Prospective Memory		.69*
Word pointing		.35
Forward Span		.32
Backward Span		.32
Pattern pointing		.28
Pattern Perseveration	-.23	
Learning		.23
Word Perseveration	-.20	

Classification results were:

Group	**# Cases**	**Predicted Group Membership** 1	2
1 Trauma	58	46.6% (n=27)	53.4% (n=31)
2 Controls	58	6.9% (n=4)	93.1% (n=54)

Percent of grouped cases correctly classified were 69.83%.

The next analyses (Verbal tasks) included prose recognition (verbatim and inferences), semantic fields, word fluency (letters, categories and perseverations). Wilks Lambda = .81, $X^2 = 21.72$, $p < .003$. The pooled within group correlations were:

<u>Function 1</u>

Word fluency: Category	.83*	
Word fluency: Letters	.74*	
Verbatim: Prose Recognition	.44*	
Inferences: Prose Recognition		.12
Category Perseveration	.08	
Letter Perseveration		.07
Semantic Fields		.04

The classification results were:

Group	# cases	Predicted Group Membership 1	2
1 Trauma	53	62.3% (n=33)	37.7% (n=20)
2 Controls	53	30.2% (n=16)	69.8% (n=37)

The percentage of grouped cases correctly classified were 66.04%.

The third analysis (Spatial and Motor) included direction following, hidden figures, motor tasks, spatial picture construction tasks. Wilks' Lambda = .79, $X^2 = 24.59$, $p < .002$. The pooled correlations were:

<u>Function 1</u>

Motor (Nail task)	-.75*
Hidden Figures (Time)	.73*

Direction Following (Time)	.61*
Direction Following (Correct)	-.56*
Motor (Clevis pin)	-.32
Spatial (Disorganized)	.27
Hidden Figures (Correct)	.11
Spatial (Organized)	.01

Group	**# Cases**	**Predicted Group Membership**	
		1	2
1 Trauma	55	65.5% (n=36)	34.5% (n=19)
2 Control	55	16.4% (n=9)	83.6% (n=46)

The percentage of grouped cases correctly classified was 74.55%.

At-Risk Sample

Descriptive characteristics: The mean age of the at-risk subjects was 72.4 years (range 49-92 yrs) and that of their controls was 72.2 yrs (range 49-100); mean education for at risk was 10.2 yrs and for their controls was 10.6 yrs.

The mean number of incorrect items on the mental status questionnaire was 1.76 for at-risk subjects and .28 for the controls, $F(1,46) = 15.49$, $p < .001$. At-risk subjects were more depressed ($M = 8.60$) than were control subjects ($M = 3.44$), $F(1,46) = 13.07$, $p < .001$ with the greatest difference occurring for the females ($Ms = 10.43$ vs 2.00), than for males ($Ms = 6.27$ vs 5.27) shown by a significant interaction of Condition X Sex, $F(1,46) = 8.11$, $p < .007$. Depression scores of the at-risk group fell within the moderately depressed range.

Analysis of Variance

Two sets of analyses of variance were done. One set dealt with a sample of 50 subjects tested only in year 1. Another ANOVAR was done on at-risk Ss and their matched controls who participated in year 1 and again about one year later. Because there were virtually no effects of retesting, analyses are reported for the larger sample. Two conditions (at-risk, control) and sex (men, women) were assigned between subjects in all analyses.

Paired Associate Learning. Proportion correct scores on the paired associate task verified the usual robustness of the task. For example, performance improved over trials, was worse on unrelated items and on abstract items. At-risk people learned less well than did their controls (M_s=.45 vs .67), $F(1,46) = 11.63$, $p < .001$. A significant condition X item relatedness X trial effect revealed that learning improved over trials more for control than for at-risk subjects, and this effect was larger for the unrelated than related items, $F(2,92) = 6.60$, $p < .002$. The highest order interaction was not enlightening beyond what was shown by lower order effects.

Working Memory. Significant Condition and Lag main effects were modifed by a Condition X Lag interaction $F(2,68)=4.40$, $p < .05$ on the working memory task . Table 6 shows that the percentage of at-risk people had significantly fewer correct responses before their first error on both the Lag 1 and 2 versions of the task.

Table 6

Percent of People Correct as a Function of

Patient and Lag Conditions

Lag		**01**	**2**
At-risk	10.00_a	6.00_b	3.74_c
Control	10.00_a	8.58_a	6.05_b

Digit Span. The Digit Span Forward was only slightly, although significantly, greater for normal (M = 6.72) than for at-risk people (M = 6.08), $F(1,46) = 5.44$, $p < .05$. Similar results were obtained for the Digit Span Backward (Ms = 5.30 for control vs 4.46 for at-risk people), $F(1,44) = 6.56$, $p < .05$.

Prospective Memory. The percentage of subjects remembering to ask for the red pen was 92 percent for control subjects and 32 percent for at-risk subjects, $F(1,38) = 6.20$, $p < .05$. Similarly fewer at-risk subjects remembered to record the time when cued by clock drawing task (Ms = .24 vs .62), $F(1/38) = 6.20$, $p < .05$. The results for the uncued prospective memory task showed striking differences, $F(1,38) = 6.70$, $p < .01$. The mean percentage of at-risk people who recorded the time on this task was 5 percent and for control people was 38 percent.

Pointing Patterns and Words. Using a strict criterion (mean number correct to the first error) on the word pointing task, at-risk subjects did more poorly than did controls (Ms =.75 vs .82), $F(1,36) = 4.81$, $p < .05$. There were no condition effects using proportion correct overall.

Using a lenient criterion on the word pointing task, at-risk subjects did more poorly than did controls (Ms = .81 vs .88),

$F(1,38) = 6.61$, $p < .01$. The significant Sex x Condition interaction was not informative. Using a strict criterion of mean correct to first error, at-risk subjects also achieved fewer correct than did control subjects (Ms = .68 vs .78), $F(1,38) = 4.48$, $p < .05$.

Prose Recognition. On the prose recognition measures, the at-risk people obtained more wrong responses than control people on the Wechsler items (Ms = .68 vs .96), $F(1,46) = 6.99$, $p < .01$, on the Dobbs-Rule items (Ms = .67 vs .87), $F(1,44) = 5.99$, $p < .05$. Overall, women did more poorly than men on the Wechsler items (Ms = .66 vs. .84) $F(1,46) = 4.06$, $p < .05$.

Semantic Fields. The proportion correct on the semantic fields task showed differences on the type of category with the functional context being worse (M = .89) than identity, superordinate, functional associate or physical attribute (Ms = .97, .94, .92, .96). Performance was worse on the contrast coordinate than any other category, (M = .67), $F(5,220) = 116.96$, $p < .001$. The interaction of Condition X Sex X Category did not yield interpretable results, $F(5,220) = 5.59$, $p < .001$.

Word Fluency. Only the total number of words correct showed significant results. At-risk subjects produced fewer correct words than did their controls (Ms= 4.24 vs 7.12), $F(1,46) = 11.12$, $p < .002$. A significant Condition X Sex interaction on number of errors in words was not interpretable.

Direction Following. No significant differences were found for direction following forward correct for each one of the six measures. The proportion correct responses averaged over all six

directions showed that controls did better than did at-risk people (Ms = .96 vs .86, respectively), $F(1,43) = 4.15$, $p < .05$. The proportion of delayed responses over six directions was greater for at-risk people (M = .18) than for controls (M = .05), $F(1,45)=5.04$, $p < .03$. Hesitations, repetitions, self-corrections, or block errors did not differ. The proportion of direction errors over six directions was higher for at-risk (M = .14) than for controls (M = .02), $F(1,43) = 4.56$, $p < .05$.

Performance on the Direction Following backwards task showed at-risk people had fewer number correct responses (Ms =. 46 vs .71), $F(1,44) = 4.15$, $p < .05$, fewer proportion correct over 6 directions (Ms = .70 vs .89), $F(1,44) = 5.08$, $p < .05$, and more errors (Ms .26 vs .06), $F(1,44) = 7.82$, $p < .001$. Men were more accurate than were women (Ms = .80 vs. .43), $F(1,44,) = 7.77$ $p < .01$.

Hidden Figures. The hidden figures pictures yielded some time effects of Type of pictures (object, part, background, parts), but there were no Conditions effects of interest.

Spatial Reconstruction. Distance measures on the spatial task showed impairment by the at-risk people on organized pictures (Ms = 48.31 vs 27.63), $F(1,38) = 14.18$, $p < .001$ and disorganized pictures (Ms = 55.40 vs 33.40), $F(1,36) = 9.93$, $p < .001$. There were no angle of rotation differences between at-risk and control people.

Motor. The mean number of clevis pins completed at 30, 60, 90, and 120 sec was fewer for at-risk (M = 8.59) than for control people (M = 10.69), $F(1,38) = 5.24$, $p < .05$ and the cumulative

performance improved linearly over time as would be expected, $F(3,114 = 425.40$ $p < .001$. A significant interaction of Condition X Time showed that normal controls cumulative performance was better than was at-risk subjects, $F(3,114) = 5.28$, $p < .01$. The mean values for at risk at 30, 60, 90, and 120 sec were 3.5, 6.79, 10.24, 13.86 respectively and for controls were 4.21, 8.50, 12.79 and 17.26 respectively. A Sex X Time interaction showed that females' performance was better at each time period than was that of males, $F(3,114) = 5.33$, $p < .01$.

Similarly, performance on the nail task was significantly worse for at risk-people ($M = 6.59$) than for normal people ($M = 9.22$), $F(1,38) = 5.69$, $p < 05$, and at each time interval (30, 60, 90 s) ($M = 3.79_c$, 7.88_b, 12.05_a), $F(2.76) = 178.62$, $p < .001$. A significant interaction showed a more accelerated improvement over time for normal subjects, $F(2,76) = 4.12$, $p < .05$.

Metamemory. On the metamemory items, there were consistent sex effects. Female at-risk Ss judged their memory to be worse than female normal subjects on how often they had memory problems, $F(1,42) = 8.64$, $p < .01$, on their memory for things in the past, $F(1,44) = 12.37$, $p < .001$, on memory now compared to 1, 5, 10 years ago, $F(1,44) = 10.09$, $p < .01$, on memory problems overall, $F(1,44) = 9.89$, $p < .01$, on prospective memory, $F(1,42) = 11.33$, $p < .002$, on retrospective memory, $F(1,44) = 12.37$, $p < .01$. At risk subjects, regardless of their sex, reported more serious retrospective problems, $F(1,42) = 5.94$, $p < .05$ and controls reported more difficulty in remembering novels, $F(1,44)$

= 4.57, $p < .05$.

Sex Differences. There were many sex effects throughout these analyses. Usually women did more poorly than did men, but this was not consistent. Sex often showed interactions with other variables, but again no consistent or interesting pattern emerged.

Test - Re-Test. There were very few re-test effects in analyses of the smaller sample, suggesting chance variations. The direction of change on the few tasks sometimes showed minimal improvement and sometimes showed minimal deterioration. The results were not instructive in any way.

Discriminant Analyses

The same groupings used in discriminant analyses for the trauma conditions were used for at-risk subjects. Discriminant analyses on the Non-Verbal tasks yielded Wilks' Lambda = .52, X^2 = 20.42, $p < .05$. The correlations were:

Tasks	**Function 1**
Prospective Memory	.87*
Learning	.66*
Forward Span	.54*
Backward Span	.52*
Word Pointing	.51*
Working Memory	.49*
Pattern Pointing	.42*
Word Perseveration	.29
Pattern Perseveration	.17

Classification results were:

Group	# Cases	Predicted Group Membership 1	2
1 At-risk	19	73.7% (n=14)	26.3% (n=5)
2 Control	19	10.5% (n=2)	89.5% (n=17)

The percentage of grouped cases correctly classified was 81.5%.

The discriminant analysis on the Verbal tasks yielded Wilks' Lambda = .74, $X^2 = 12.52$, $\underline{p} < .08$. The two groups could not be significantly separated along a dimension.

The discriminant analysis on the spatial and motor tasks yielded a Wilks' Lambda of .59, $X^2 = 18$, $\underline{p} <$ 05. The resulting correlations were:

Tasks	Function 1
Spatial (Organized)	.72*
Spatial (Disorganized)	.62*
Motor (Clevis)	.41*
Motor (Nail)	.40*
Hidden Figures (Correct)	.39
Direction Following (Correct)	.31
Hidden Figures (Time)	.30
Direction Following (Time)	.28

Classification Results were:

Group	# Cases	Predicted Group Membership 1	2
1 At-risk	20	75% (n=15)	25% (n=5)
2 Controls	20	15% (n=3)	85% (n=17)

The percentage of grouped cases correctly classified was 80%.

Conclusions

Analyses of variance results clearly indicated deficits on a wide range of memory and cognitive tasks. These results showed that as a group people who had experienced trauma or were likely candidates for Alzheimer's disease were deficient. There is no doubt that both groups suffer impairments: Learning, working memory, prospective memory, word pointing, Dobbs-Rule prose recognition, word fluency, direction following forward (time and correct), direction following back (correct) and spatial (picture) reconstruction. Several measures were significantly different for either the trauma or the at-risk groups and vice versa. The at-risk groups, but not trauma groups, were also impaired on digit span forward and backward, pattern pointing. The trauma group, but not at-risk patients, were impaired on word fluency letters and category plus letters as well as direction following back (time) and hidden figure (time).

The analysis used to identify patterns that might discriminate the patient groups from their controls was discriminant analysis. Discriminant analyses of the learning, memory and non-language cognitive tasks revealed that, although working memory and prospective memory significantly distinguished trauma victims from their non-trauma controls, their correct classification occurred on a chance basis, whereas 93% of their normal controls were correctly classified. The second analysis on verbal tasks showed that word fluency and verbatim recognition for prose successfully distinguished the trauma from non-trauma subjects. However, the correct classification, although improved

for trauma subjects (62.3% or 33 versus 20 people), was not quite as good for normal subjects as in the nonlanguage memory tasks (69.8% or 37 versus 16 people). The third analysis indicated that motor performance (nail tasks), direction following and hidden figures task discriminated the two groups, correctly classifying trauma subjects in 65.5% of the cases (36 versus 19 people), and control S's in 83.6% of the cases (46 versus 19 people).

Thus, although there are group differences on many tasks, one needs to be concerned about the performance of post-injured people especially according to the cognitive and safety demands of their job. If, however, identification of those who are significantly impaired is important, testing on tasks that tap the slowing of responses is necessary to assist in correct classification of individuals as trauma-impaired or normal. Usually, this specific type of clinical classification will not be relevant to job-related issues. More important is the capabilities of the person to perform his or her job effectively and safely, regardless of clinical diagnosis.

The same groups of measures isolated significant discriminators for at-risk and their matched controls. Prospective memory, learning, digit span forward and backward, pattern and word pointing discriminated 73.7% (14 vs 5) of the at-risk and 89.5% (17 vs 2) of the normal control cases successfully and spatial and motor (nail) task performance successfully identified 75% (15 vs 5) of the at-risk and 85% (17 vs 3) of the normal control subjects. In the case of memory-

impaired people who have not experienced head or neck injuries, memory, cognitive, spatial and motor task performance will assist in their correct identification. As with trauma victims the overall match between cognitive job requirements and abilities is more important than the diagnosis attributed to the impairment.

The relevance of our results to the workplace is that when the demographics of the workplace reflect an increasingly older population, information about likely dementia will be quite relevant to productivity and safety issues. Approximately 15% of people over 65 will have dementia, and the process starts at least 5-10 years before it is diagnosed.

The predictors of cognitive performance in minor head injuries and whiplash are of considerable interest. We isolated several types of potential predictors. Although specific post-trauma symptoms, as well as general emotional and physical health problems characterize our sample, none of these variables emerged as consistent predictors of cognitive impairment.

Although age, among the demographic variables, and number of past head injuries, among the accident variables, predicted performance on many of cognitive variables, they did not compete successfully when pitted against age at the time of accident. Age at the time of accident accounted for performance on many cognitive tasks overall, and predicted performance on five of the eight tasks in the discriminant analysis. The confounding of chronological age and age at the time of the accident cannot be disentangled, however. Depression accounted for performance on prospective memory only on the remaining tasks.

There were several noteworthy lack of results. There was a relatively low proportion of subjects in litigation at time of testing and the relative contribution of litigation did not account for performance in regression analyses.

As shown in regression analyses, there was no evidence of differences between head injured and whiplash victims. This result is consistent with presumptions about their similar neurophysiological underpinnings.

Unfortunately, there was no evidence of recovery in trauma victims. Retesting showed virtually no changes in performance. Perhaps a longer time period between testing would show recovery. Although trauma victims report more memory problems (metamemory) compared to their controls than do at-risk compared to their controls, beliefs about memory do not discriminate performance deficits for the most part. Their deficits are more time pressure oriented rather than memory per se. Metamemory tests do not assess these factors but the implication is that clinicians should not use subjective reports about memory as a valid indicator of the types of deficits that exist.

Number of drugs taken did not emerge as a predictor of performance, although 90% of the male and 78% of the female subjects were taking pain killers, tranquilizers, or sleeping pills. However, drug dosage was not measured. Further work should ascertain the contribution made by actual drug consumption to cognitive performance.

Despite the fact that only approximately thirty percent of persons having had a minor head or whiplash injury experience the

post traumatic symptoms, our data show that these people suffer cognitive impairment, on average of two-and-one-half years post-injury. Moreover, a battery of tests can discriminate them fairly well from age and education matched controls.

There are several important implications from the findings on this project. First, this test battery may serve as a tool to identify those persons who may have cognitive deficits that could impair their job performance or safety on the job. For the battery to be a clinically useful tool, however, further research must be done to examine its discriminability from other specific pathologies, as well as accidents of exposure to chemical neurotoxins.

Second, in our research program, we have identified cognitive dysfunction in people with minor head injury, whiplash, at-risk for dementia, and to a lesser extent, for adults over 65 years of age with this test battery. The varied causes of specific memory and cognitive disorders have heretofore not been identified because of the focus on using neuropsychological tests sensitive for identifying severe impairments or intelligence tests that reflect stable and gross attributes of cognition. With a battery that enables detection of early or specific memory and cognitive dysfunction, the implications for both productivity and safety in the workplace can be explored.

If there is a mismatch between job requirements and cognitive abilities, it is apparent that productivity may suffer because of lack of appropriate abilities to handle job demands. Similarly, if a person is cognitively unfit for certain tasks, as may be the

case in an aging air controller, the safety of many other people may be in jeopardy.

With the advent of an aging workforce in the next few years, these issues may be of utmost importance for business and industry. Research steps need to be taken soon to prepare for this new challenge.

In closing this report, it is clear that our goals have been met. There are obvious implications from the results. And, there are evident directions for continued research along the lines we have suggested.

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Table 7
Demographic Variables: Stepwise Regression Analyses
Trauma Condition

Variables Entered: SEX, AGEYR, EDUCATION

Task	Predictive Variables	BETA	SIG F	R_2
Paired Associates Proportion Correct	AGE	-.261	.025	.068
Digit Span Forward	EDUC	.385	.0007	.149
Digit Span Backward	EDUC	.341	.0003	.116
Working Memory Lag 1	AGE	-.331	.002	.165
	SEX	-.237		
Prospective Memory		None		
Prose Recognition Verbatim	AGE	-.283	.0147	.080
Prose Recognition Inference		None		
Direction Following Correct	SEX	-.233	.045	.055
Direction Following Time	SEX	.332	.004	.110
Frontal Patterns Correct	AGE	-.255	.028	.065
Frontal Patterns Preservation		None		
Hidden Figures Time	AGE	.360	.0003	.205
	SEX	.277		
Hidden Figures #Correct	AGE	-.263	.024	.069
Clevis & Pin Task	AGE	.494	.0000	.244
Nail Task	AGE	-.319	.0006	.189
	SEX	-.299		

Task	Predictive Variables	Beta	Sig F	R^2
Semantic Fields Related Correct		None		
Word Fluency Letter Correct	EDUC	.488	.0000	.238
Word Fluency Letter Perseveration		None		
Word Fluency Category Correct	AGE	-.319	.006	.102
Word Fluency Category Perseveration		None		
Spatial Picture Re-Construction Correct		None		
Spatial Picture Re-Construction Incorrect		None		
Frontal Words Correct	EDUC	.255	.028	.065

Table 8
Accident Variables: Regression Analyses
Trauma Condition

Variables Entered: Number of accidents, head injury, whiplash, injury, time since accident and loss of consciousness, age at accident, litigation

Task	Predictive Variables	BETA	SIG F	R_2
Paired Associates Proportion Correct	AGEACC	-.314	.009	-.098
Digit Span Forward		None		
Digit Span Backward	AGEACC	-.321	.008	.103
Working Memory Lag 1			.0012	.189
	AGEACC	-.317		
	INLITDUR	-.266		
Prospective Memory		None		
Prose Recognition Verbatim	AGEACC	-.292	.017	.085
Prose Recognition Inference	AGEACC	-.254	.0399	.064
Direction Following Correct	INLITDUR	-.248	.043	.061
Direction Following Time	AGEACC	.270	.027	.073
Frontal Patterns Correct	AGEACC	-.316	.009	.10
Frontal Patterns Preservation		None		
Hidden Figures Time	AGEACC	.360	.003	.129
Hidden Figures #Correct	AGEACC	-.281	.021	.079
Clevis & Pin Task	AGEACC	-.502	.000	.252
Nail Task	TIMEYR	-.339		
	AGEACC	-.301		

Task	Predictive Variables	Beta	Sig F	R^2
Semantic Fields Related Correct	TIMEYR	-.290	.019	.084
Word Fluency Letter Correct	AGEACC	-.259	.036	.067
Word Fluency Letter Perseveration		None		
Word Fluency Category Correct	AGEACC	-.400	.0009	.160
Word Fluency Category Perseveration	HDINJ	.263	.033	.069
Spatial Picture Re-Construction Correct		None		
Spatial Picture Re-Construction Incorrect	LOC	.262	.034	.069
Frontal Words Correct	AGEACC	-.251	.041	.063
Frontal Words Perseveration		None		

Table 9
Health Variables: Regression Analyses
Trauma Condition

Variables Entered: Physical Health, Mental Health, Drugs loss of consciousness

Variable	Predictive Variables	BETA	SIG F	R_2
Paired Associates Proportion Correct	Physical Health	-.366	.026	.134
Digit Span Forward	None			
Digit Span Backward	None			
Working Memory Lag 1	None			
Prospective Memory	None			
Prose Recognition Verbation	Drugs	-.332	.045	.110
Prose Recognition Inference	None			
Direction Following Correct	None			
Direction Following Time	None			
Frontal Patterns Correct	None			
Frontal Patterns Perseveration	None			
Hidden Figures Time	Physical Health	.364	.026	.133
Hidden Figures # Correct	Physical Health	-.331	.045	.109
Clevis & Pin Task	None			
Nail Task	Physical Health	-.430	.008	.185
Semantic Fields Related Correct	Drugs	.457	.005	.209

Variable	Predictive Variables	BETA	SIG F	R_2
Word Fluency Letter Preseveration	None			
Word Fluency Category Perseveration	None			
Word Fluency Category Perseveration	None			
Spatial Picture Re-Construction Correct	None			
Spatial Picture Re-Construction Incorrect	None			
Frontal Words Correct	None			
Frontal Words Perseveration	None			

Table 10
Metamemory and Depression: Regression Analyses
Trauma Condition

Variables Entered: Depression, overall memory, memory now compared to past

Variable	Predictive Variables	BETA	SIG F	R_2
Paired Associates Proportion Correct	Depression	-.315	.006	-099
Digit Span Forward	Depression	-.275	.0176	.076
Digit Span Backward	Depression	-.245	.0353	.060
Working Memory Lag 1	Overall metamemory	.287	-0113	.082
Prospective Memory	Depression	-.324	.0058	.105
Prose Recognition Verbation	None	-.332	.045	.110
Prose Recognition Inference	None			
Direction Following Correct	Overall Metamemory	.262	.024	.068
Direction Following Time	None			
Frontal Patterns Correct	Memory: Past	.231	.047	.053
Frontal Patterns Perseveration	None			
Hidden Figures Time	None			
Hidden Figures # Correct	None			
Clevis & Pin Task	Overall Metamemory	.305	.008	.093
Nail Task	Depression	-.258	.026	-.067

Variable	Predictive Variables	BETA	SIG F	R_2
Semantic Fields Related Correct	None			
Word Fluency Letter Correct	Depression	-.372	.001	.138
Word Fluency Letter Perseveration	None			
Word Fluency Correct	Depression	-.236	.044	.056
Word Fluency Category Perseveration	None			
Spatial Picture Re-Construction Correct	Memory: Past	-.302	.009	.0915
Spatial Picture Re-Construction Incorrect	None			
Frontal Words Correct	None			
Frontal Words Perseveration	None			

Table 11
Post Traumatic Syndrome Variables
Regression Analyses
Trauma Condition

Variables Entered: Personality change, sex drive change, severity of headache, memory change

Variable	Predictive Variables	BETA	SIG F	R_2
Paired Associates Proportion Correct	Personal-ity	-.263	.036	.069
Digit Span Forward	Personal-ity	-.289	.0203	.034
Digit Span Backward	Headache	-.485	.0000	.235
Working Memory Lag 1	Personal-ity	.259	.0374	.066
Prospective Memory	None			
Prose Recognition Verbatim	Sex Drive	-.259	.0357	.067
Prose Recognition Inference	None			
Direction Following Correct	Headache	.271	.030	.073
Direction Following Time	None			
Frontal Patterns Correct	None			
Frontal Patterns Perseveration	None			
Hidden Figures Time	None			
Hidden Figures # Correct	Personal-ity	-.260	.0376	.068
Clevis & Pin Task	None			
Nail Task				
Semantic Fields Related Correct	None			

Variable	Predictive Variables	BETA	SIG F	R_2
Word Fluency Letter Correct	Headache	-.379	.0022	.143
Word Fluency Letter Perseveration	None			
Word Fluency Correct	None			
Word Fluency Category Perseveration	None			
Spatial Picture Re-Construction Correct	None	-.302	.009	
Spatial Picture Re-Construction Incorrect	None			
Frontal Words Correct	None			
Frontal Words Perseveration	None			

Table 12
Final Predictors: Regression Analysis

Variables Entered: number of accidents, age at accident, education, and depression.

Variable	Predictive Variables	BETA	SIG F	R_2
Paired Associates	Depression	-.372	.0002	.213
Paired Associates Proportion Correct	AGEACC	-.342		
Digit Span Forward	Education	.386	.0007	.149
Digit Span Backward	Education AGEACC Depression	.260 -.265 -.226	.008	.211
Working Memory Lag 1	AGEACC	-.319	.0057	.101
Prospective Memory	Depression	-.324	.0058	.105
Prose Recognition Verbatim	AGEACC	-.306	.0080	.094
Prose Recognition Inference	None			
Direction Following Correct	None			
Direction Following Time	None			
Frontal Patterns Correct	AGEACC Depression	-.306 -.245	.0075	.129
Frontal Patterns Perseveration	None			
Hidden Figures Time	AGEACC	.321	.0053	.103
Hidden Figures # Correct	AGEACC	-.260	.0251	.068
Clevis & Pin Task	AGEACC	-.470	.0000	.220
Nail Task	Depression	-.309	.0024	.157
Semantic Fields Related Correct	None			

Variable	Predictive Variables	BETA	SIG F	R_2
Word Fluency Letter Correct	Education Depression	.389 -.303	.0000	.344
Word Fluency Category Perseveration	None			
Word Fluency Category Correct	AGEACC	-.396	.0003	.209
Word Fluency Category Perseveration	None			
Spatial Picture Re-Construction Correct	Depression	.248	.0347	.061
Spatial Picture Re-Construction Incorrect	None			
Frontal Words Correct	Education	.255	.0285	.065
Frontal Words Perseveration	None			

Alberta Occupational Health

and Safety Report

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Summary of Activities

Published Abstracts

Aubrey, J. B., Dobbs, A. R., Rule, B. G., & Vanast, W. (1987). Popular concepts of "whiplash" symptoms: Further evidence against malingering. Canadian Journal of Neurological Sciences, 14, 237.

Aubrey, J. B., Dobbs, A. R., Rule, B. G. & Vanast, W. J. (1987). The cognitive and affective sequelae of whiplash injuries: A pilot study of laypersons' awareness. Headache, 12, 48.

Aubrey, J. B., Dobbs, A. R. & Rule, B. G. (1987). Laypersons' knowledge about the physical and mental sequelae of whiplash. Canadian Psychology, 28(2a), Abstract No. 16.

Schwartzberg, S., Dobbs, A. R., Rule, B. G., & Vanast, W. J. (1988). Minor head injury and immediate memory. Canadian Psychology, 29(2a), Abstract No. 706.

Dobbs, A. R., Rule, B. G. & Vanast, W. J. (1988). Psychological sequelae of minor head injury and cognitive dysfunction. Canadian Psychology, 29(2a), Abstract No. 199.

Conference Presentations

Dobbs, A. R. (1987). The effects of minor head injury and whiplash on prospective remembering, working memory and retrieval. Workshop on Issues in the Assessment and Treatment of Minor Head Injury. Meetings of the Psychologists Association of Alberta, Jasper.

Rule, B. G. (1988, November). Cognitive dysfunction in minor head injury and whiplash. Paper presented at the Annual Meeting of the Alberta Occupational Health Society.

Publications

Aubrey, J. B., Dobbs, A. R. & Rule, B. G. (1989). Laypersons' knowledge about the sequelae of minor head injury and whiplash. Journal of Neurology, Neurosurgery, and Psychiatry, 52, 842-846.

Dobbs, A.R., Schwartzberg, S., Aubrey, J. B. & Rule, B. G. Cognitive consequences of minor head injury and whiplash. In preparation.

Rule, B. G., Edguer, B., Schwartzberg, S. & Dobbs, A. R. Predictors of neurocognitive sequelae of minor head injury and whiplash. In preparation.

Isaak, B., Rule, B. G. & Dobbs, A. R. The influence of depression and minor head injury on cognitive deficits. In preparation.